非递归下降分析器

- 消除间接左递归方法

例：

$$S \to Qc|c$$
$$Q \to Rb|b$$
$$R \to Sa|a$$

过程：
(1)代入化简，将间接左递归变成直接左递归
将R的产生式代入Q的产生式，得到
$Q \to Sab|ab|b$
将Q的产生式代入S的产生式，得到
$S \to Sabc|abc|bc|c$
(2)消除直接左递归，得到的结果与Q和R无关，可删去Q和R的产生式
$S \to abcS'|bcS'|cS'$
$S' \to abcS'|\varepsilon$

- 简化文法，仅包含while循环的文法分析

注：以空格分隔各符号（终结符与非终结符）

$$(0) program \to block$$
$$(1) block \to \{\ stmts\ \}$$
$$(2) stmts \to stmt\ stmts$$
$$(3) stmts \to \varepsilon$$
$$(4) stmt \to id\ =\ expr\ ;$$
$$(5) stmt \to while\ (\ bool\ )\ stmt$$
$$(6) stmt \to block$$
$$(7) bool \to expr\ bool'$$
$$(8) bool' \to <\ expr$$
$$(9) bool' \to <=\ expr$$
$$(10) bool' \to >\ expr$$
$$(11) bool' \to >=\ expr$$
$$(12) bool' \to \varepsilon$$
$$(13) expr \to term\ expr''$$
$$(14) expr'' \to expr'\ expr''$$
$$(15) expr'' \to \varepsilon$$
$$(16) expr' \to +\ term$$
$$(17) expr' \to -\ term$$
$$(18) term \to factor\ term''$$
$$(19) term'' \to term'\ term''$$
$$(20) term'' \to \varepsilon$$
$$(21) term' \to *\ factor$$
$$(22) term' \to /\ factor$$
$$(23) factor \to (\ expr\ )$$
$$(24) factor \to id$$
$$(25) factor \to num$$

- 手工构造分析表

	{	}	id	=	;	while	(	)	<	<=	>	>=	+	-	*	/	num
program	$program \rightarrow block$																
block	$block \rightarrow \{stmts\}$																
stmts	$stmts \rightarrow stmt\ stmts$	$stmts \rightarrow \varepsilon$	$stmts \rightarrow stmt\ stmts$			$stmts \rightarrow stmt\ stmts$											
stmt	$stmt \rightarrow block$		$stmt \rightarrow id = expr;$			$while(bool)stmt$											
bool			$bool \rightarrow expr\ bool'$				$bool \rightarrow expr\ bool'$										$bool \rightarrow expr\ bool'$
bool'								$bool' \rightarrow \varepsilon$	$bool' \rightarrow < expr$	$bool' \rightarrow <= expr$	$bool' \rightarrow > expr$	$bool' \rightarrow >= expr$					
expr			$expr \rightarrow term\ expr'$				$expr \rightarrow term\ expr'$										$expr \rightarrow term\ expr'$
expr'													$expr' \rightarrow +term$	$expr' \rightarrow -term$			
expr''					$expr'' \rightarrow \varepsilon$			$expr'' \rightarrow \varepsilon$	$expr'' \rightarrow \varepsilon$	$expr'' \rightarrow \varepsilon$	$expr'' \rightarrow \varepsilon$	$expr'' \rightarrow \varepsilon$	$expr'' \rightarrow expr'\ expr''$	$expr'' \rightarrow expr'\ expr''$			
term			$term \rightarrow factor\ term''$				$term \rightarrow factor\ term''$										$term \rightarrow factor\ term''$
term'															$term' \rightarrow *factor$	$term' \rightarrow /factor$	
term''					$term'' \rightarrow \varepsilon$			$term'' \rightarrow \varepsilon$	$term'' \rightarrow \varepsilon$	$term'' \rightarrow \varepsilon$	$term'' \rightarrow \varepsilon$	$term'' \rightarrow \varepsilon$	$term'' \rightarrow \varepsilon$	$term'' \rightarrow \varepsilon$	$term'' \rightarrow term'\ term''$	$term'' \rightarrow term'\ term''$	
factor			$factor \rightarrow id$				$factor \rightarrow (expr)$										$factor \rightarrow num$

- 求First集、Follow集

$$
\begin{aligned}
&First(program) = \{\ \{\ \} \\
&First(block) = \{\ \{\ \} \\
&First(stmts) = \{id, while, \{, \varepsilon\} \\
&First(stmt) = \{id, while, \{\ \} \\
&First(bool) = \{(, id, num\} \\
&First(bool') = \{<, <=, >, >=, \varepsilon\} \\
&First(expr) = \{(, id, num\} \\
&First(expr') = \{+, -\} \\
&First(expr'') = \{+, -, \varepsilon\} \\
&First(term) = \{(, id, num\} \\
&First(term') = \{*, /\} \\
&First(term'') = \{*, /, \varepsilon\} \\
&First(factor) = \{(, id, num\}
\end{aligned}
$$

$$
\begin{aligned}
&Follow(program) = \{\#\} \\
&Follow(block) = \{\#, id, while, (, \}\ \} \\
&Follow(stmts) = \{\ \}\ \} \\
&Follow(stmt) = \{id, while, (, \}\ \} \\
&Follow(bool) = \{)\} \\
&Follow(bool') = \{)\} \\
&Follow(expr) = \{), <, <=, >, >=, ;\} \\
&Follow(expr') = \{+, -,), <, <=, >, >=, ;\} \\
&Follow(expr'') = \{), <, <=, >, >=, ;\} \\
&Follow(term) = \{+, -,), <, <=, >, >=, ;\} \\
&Follow(term') = \{*, /, +, -,), <, <=, >, >=, ;\} \\
&Follow(term'') = \{+, -,), <, <=, >, >=, ;\} \\
&Follow(factor) = \{*, /, +, -,), <, <=, >, >=, ;\}
\end{aligned}
$$